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ABSTRACT

The PipeLINK program seeks to attract and retain women and girls in computer science careers. Aimed at girls and women from the high school through the Ph.D. levels, the program suggests activities to aid participants at each level, connect students with role models and mentors, and provides an introduction to a wide variety of computer science topics. The participants in the program were undergraduate and graduate students, university faculty, high school students, and high school teachers. During one academic year, activities consisted of 16 high school visits; 3 high school teacher workshops; 2 high school activity days at Rensselaer Polytechnic Institute; monthly undergraduate and graduate lunch meetings; and participation in an electronic mentoring network, consisting of bulletin boards, chat groups, and e-mail. During the summer of 1995, 2 programs were held at Rensselaer: a 10-week undergraduate research program, and a 2-week high school program. The evaluation of the program was conducted through questionnaires. Most of the undergraduate and graduate students who participated in the PipeLINK activities are still students, so it is too early to determine whether the program is achieving its goal of retaining women in computer science. However, anecdotal evidence shows some participants planning to become visible female role models for future computer scientists. For the high school participants, responses were positive and indicated that the most popular aspects of the electronic mentoring network were e-mail and Internet. (AEF)

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Paper

PipeLINK: Connecting Women and Girls in the Computer Science Pipeline

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Key Words: **computer science, women, pipeline**

Abstract

The PipeLINK program seeks to attract and retain women and girls into careers in computer science. Aimed at girls and women from the high school through the Ph.D. level, the program provides activities to aid participants at each level, find role models and mentors from the levels above, as well as an introduction to a wide variety of computer science topics. This paper describes PipeLINK activities that were carried out during the academic year 1994–95 and the summer of 1995, including an evaluation of their effectiveness.

1. Introduction

A common theme in discussions about the underrepresentation of women in science these days is the "pipeline" metaphor; women enter the pipeline to a scientific career in high school, but the pipeline narrows (i.e. a higher percentage of women drop out) as the level of study increases. This effect is extremely clear in computer science, where high school girls and boys show interest in computer science in nearly equal numbers, but only a very small percentage of the full professors in the field of computer science are women. One goal of PipeLINK* is to attract more girls at the high school level to the study of computer science, by making sure they are aware of the field and its opportunities. A second goal is to retain women in the pipeline; i.e. to increase the number of females at each educational level from high school through the Ph.D. who continue in the study of computer science.

The PipeLINK program addresses retention by creating a women's network, connecting several levels of the pipeline (high school students, undergraduate students,

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graduate students, as well as women faculty) so that women at each level see role models at the higher levels, and additionally so that women at each level will themselves be role models and mentors to women at the earlier levels. With these connections, not only do women benefit from role models and informal mentoring from more senior women, but they also reap the rewards of being role models themselves. To encourage these connections, we created an electronic mail network for girls at the high school, with participation by undergraduate, graduate, and faculty women interested in computer science. Face-to-face contact was also encouraged via a number of on-site activities. We sponsored talks and visits by senior women faculty to Rensselaer and by Rensselaer faculty and students to high schools. High school students were invited to attend activity days at Rensselaer. Finally, we included high school, undergraduate, and graduate women in a summer program of research and enrichment in computer science.

Many women in computer science are choosing not to get an advanced degree. Articles discussing women in computing point out that there is a "pipeline shrinkage" as women move through the pipeline from high school, to an undergraduate degree, to a Ph.D. [3, 6, 5] A 1990 National Science Foundation survey showed that approximately 50% of students in high school computer science courses were women [4]. Using longitudinal statistics available from the computing research association [2], we can follow a hypothetical "class" of computer scientists: in 1985, the percentage of women among B.S./B.A. recipients in CS was 37%, in 1989, the percentage of women among M.S. recipients was only 28%, and among Ph.D. Recipients in 1991, the percentage of women was only 15%.

The most recent (1994) statistics at the university level show that the number of women is consistently low: 18% for B.S./B.A. degrees, 19% for M.S. degrees, and 16% for Ph.D. degrees in computer science and engineering [5]. Further along the educational pipeline, the number of women in computer science drops precipitously: 18% of assistant professors are women, but only 9% of associate professors and 5% of full professors of computer science or computer engineering are women. Two issues cited for this "pipeline shrinkage" are lack of role models and lack of self-esteem among women [1, 9, 8].

In this paper, we describe our PipeLINK program, including activities that introduce technical areas of computer science to the participants while concurrently connecting them with older female role models. Section 2 of the paper describes the participants in the program, then Sections 3 and 4 describe the academic-year and summer activities, respectively. Finally, Section 5 presents an evaluation of our program, including both immediate feedback and end-of-year feedback (for the academic-year portion of the program).

2. Participants

The participants in our program were undergraduate and graduate students, university faculty, high school students, and high school teachers. The majority of the university participants were in the area of computer science and from Rensselaer. The 16 participating high schools were a mix of public and private schools in the Albany-Troy, New York, area—all close to Rensselaer. The high school teacher contacts at the schools were mostly from the areas of advanced mathematics or computer science. The majority of participating students, faculty and invited speakers, and many of the high school teachers were female.

During the academic year, activities were open to all potential participants on a first-come, first-serve basis, until no more space was available. Overall, participants included approximately 60 high school girls who visited Rensselaer, approximately 1,000 high school students (boys and girls) who attended talks at their high schools, 15 undergraduate computer science majors, and ten graduate computer science majors.

Although the last two numbers look small, they represent 42% of the female undergraduate computer science majors and 47% of the female graduate computer science majors at Rensselaer. In addition, we had one or two primary contact teachers at each participating high school who came to training workshops that we held, and many of whom participated in activities with their girls. Although parents were not targeted, several parents attended one of our activity days at Rensselaer, and many parents participated in the summer program by attending at least one of the two scheduled visitor's days.

For the summer programs, eight undergraduate students from throughout the United States, and 20 high school students from our participating high schools were chosen. The undergraduates were chosen from over 40 applicants on the basis of their scholastic excellence, mentoring experience, enthusiasm for the program, and preparation to carry out undergraduate research. The high school students were nominated by their teachers (each teacher was asked to nominate a primary candidate and an alternate, and we took as many alternates as we could). Of the 16 participating schools 14 were represented in the summer program. Additionally, two Rensselaer women graduate students were hired to be TA's and to develop materials and activities for both summer programs.

3. PipeLINK Academic Year Activities

During the academic year, activities consisted of 16 high school visits, three high school teacher workshops, two high school activity days at Rensselaer, monthly undergraduate and graduate lunch meetings, and participation in an electronic mentoring network, consisting of bulletin boards, chat groups, and e-mail. Each high school was visited by a female professor and a female student of computer science, who made presentations highlighting interesting applications of computer science.

These presentations consisted of several different modules of approximately ten minutes long, including one developed by the student. Topics covered in presentations included robotics, graphics, computer vision, algorithms, computational complexity, the Internet, and the history of computing. Most graduate students presented modules about their research area, and most undergraduate students prepared modules describing what they had learned in a favorite course. The high school students reacted very positively to the university student presentations, often spending time after the session discussing issues informally with the university students.

The high school teacher workshops were held at the beginning, middle, and end of the academic year. At the first workshop, we presented the program's goals and brainstormed about activities that would attract girls' interests. At the second, we evaluated the high school visits, and trained teachers on the electronic mentoring system (this system did not come online until January). The third workshop was held primarily for program evaluation.

The high school activity days were a highlight of the academic year portion of the PipeLINK program. Each session had two activities: Internet surfing and either simulating mathematical models of "Growing Plants and Trees" or practice with the PipeLINK electronic network. In addition to the faculty leaders, each activity day session had two to four female Rensselaer student helpers, who walked around the room and assisted students who had some difficulty. These helpers and session leaders had a chance to get to know some of the girls individually.

The electronic mentoring network provided e-mail, chat, and bulletin board services for the high school students, high school faculty, and undergraduate and graduate computer science students at Rensselaer. After the second activity day, we added Internet access to the system, because of demand from the students and teachers. We had some technical difficulties which delayed making the system available until January.

but once the system became available, the girls began using it, especially for e-mail and the Internet.

The activities for undergraduate and graduate women computer science students at Rensselaer consisted primarily of monthly informal lunch meetings, where issues of interest to women were discussed. The first of these was a dinner meeting where the PipeLINK program was outlined. At subsequent meetings, issues discussed included the academic atmosphere for women in computer science at Rensselaer; the current job market, especially for women; tips on choosing courses, advisors, and thesis topics; and the variety of paths that we followed into computer science.

Another activity sponsored by the PipeLINK program for Rensselaer participants was the invitation of a distinguished woman computer scientist to speak in Rensselaer's Computer Science Colloquium. Through the PipeLINK mailing list, women computer science students were invited to three additional computer science colloquia presented by women in the 1994–95 academic year, as well as a presentation to the ACM student chapter about some of the issues facing women in computer science.

4. PipeLINK Summer Activities

During the summer of 1995, two programs were held at Rensselaer: a ten-week undergraduate research program, and a two-week high school program. In the undergraduate program, eight women undergraduates from throughout the United States conducted research projects under the direction of women faculty or graduate students. These women also served as teaching assistants (and "counselors") for the high school program that was held during the last two weeks of the summer. In the high school program, 20 girls from 14 high schools experienced a wide variety of areas of computer science through laboratory activities, lectures by computer scientists from Rensselaer and other institutions, and visits to industry sites.

The eight undergraduate participants were matched with six mentors (two mentors took two students each). Since there is only one female computer science professor at Rensselaer, the mentors also included women faculty in mathematics and mechanical engineering, and female Ph.D. students (all three student mentors were in the final stage of the Ph.D. program) in computer science, and electrical and computer systems engineering. The undergraduate research topics included computer simulation of heat transfer, computer vision, computer supported collaboration [2], geometric algorithms, fuzzy logic, neural networks, and machine learning.

During the summer, all undergraduate participants met for weekly lunch discussions, with the leader rotated among the undergraduates. Topics discussed included topics of interest to women as well as computer scientists, including: "Women in Computer Science," "Net Censorship," "The Information Superhighway," "Co-ed vs. Single-sex Schools," "All About Grad School," and "What We Like about Computer Science." This last topic overlapped with the participants in the high school program.

At the end of the program, each undergraduate made a research presentation to the high school students and other undergraduates. The mentors helped the undergraduates prepare their talks, suggesting visual aids wherever possible. As a result, all the presentations were well prepared and captivated the high school students. The undergraduates' enthusiasm showed that they had found their research work interesting.

The high school program participants were nominated by their teachers. Most had completed their sophomore or junior year in high school, although many of them had no coursework in computer science. During the course of the program, the girls participated in 11 labs, including communicating via e-mail and chat, creating their own home pages on the World Wide Web, developing their own computer animations,

creating guessing games using probabilistic reasoning, and learning to program in C++ [7]. Lab instructors were assisted by members of the undergraduate research program as TA's. The program also included nine lectures on areas as diverse as databases, computing languages, symbolic mathematics and robotics, and had three field trips, visiting laboratories on Rensselaer's campus, a local startup company, and a nearby international corporation's research laboratory. To increase the degree of informal contact between undergraduate and high school participants, undergraduates were scheduled to eat meals with the high school girls and to lead evening activities.

During the high school program, both the undergraduate and high school students met many female computer science role models. In addition to the female graduate students and professors at Rensselaer, the students met two female professors and one female Ph.D. student (in the final stage of her Ph.D.) from other Universities who gave interactive talks. In addition, the participants visited a local industrial site where seven women from different areas of the company gave a short talk on their work and how they got to this point in their career.

5. Evaluation

During the academic year, the evaluation of our program was conducted through questionnaires at the end of the year, in addition to the end of each workshop and activity day. During the summer, questionnaires were given at the end of each week for the high school program, and at the end of the summer for the undergraduate program.

The evaluation at the teacher's workshop included questions about the school visits. Twelve of fifteen teachers responding wrote that the students' overall reaction to the visit was positive or very positive. These evaluations also showed that one feature that was missing from the PipeLINK program was support for the teachers in learning to use the electronic mentoring network and the Internet. In future programs, we plan to assign an undergraduate helper to each high school to aid the teachers and students in using our system.

Over sixty girls attended the four half-day activity days held at Rensselaer. The evaluation questionnaires we handed out at the end of each activity were very positive. One student wrote about the first activity day, "I found today's activities to be very educational in a fun way. I really enjoyed the Internet hunt and trying to figure out the other questions that were submitted. It was fun and challenging, and I learned a lot about the Internet System." At the second activity day, we asked students whether it was their first or second time, and why they had come. 100% of the second-timers wrote that they returned because of their positive experiences at the first activity day. For example, one wrote "it was fun last time," and another wrote "because I enjoyed the first so much." At the end of the second activity day, more than half of the responses to the question "Do you have any other comments for us about today's activities?," mentioned that the activity was fun or enjoyable, for example, "I had a really great time, keep it up. I'll be back next year if this happens again!" Overall, 82% of the respondents to the year-end questionnaire wrote that they would attend future activity days if offered.

Responses to our academic year-end questionnaire indicated that the most popular aspects of the electronic mentoring network were e-mail and Internet (60% of respondents used each regularly). Fewer girls were using the electronic chat (41%) and bulletin boards (32%) on a regular basis. The year-end questionnaires showed that the PipeLINK program primarily achieved its goal of introducing high school girls to the opportunities in computer science. Approximately 75% of the girls who answered the question, "Did any part of the program affect your interest in computer science?" answered affirmatively. Many answers echoed the comment of one student, "I've learned more about computers and the Internet. I think the Internet is great because

there is so much info for everyone. PipeLINK showed me about computer science and now I know what it is, how it's used, and in college, I plan to take computer science because it interests me greatly." One of the motivating factors for many of these girls was the use of computers for communication. In addition to many girls who mentioned the Internet, others referred to additional forms of communication, for example: "I was interested when I learned that you could contact & meet new people over the computer." The PipeLINK program was successful at the high school level both in attracting girls to computer science, and in breaking the stereotypes of how computers are used and who generally uses them.

Undergraduate and graduate students benefited from role models and from themselves being role models. One graduate student wrote, "I think that most of the activities were great, and that they went a long way toward addressing the problem at hand." An undergraduate wrote that one session "was very helpful on a personal level for understanding more about the role of women in computer related fields; very informative." After our Distinguished Professor's visit, many positive comments were made by both women and men about her talk. One woman graduate student wrote, "It is always encouraging to me when a woman computer scientist gives an interesting and well-presented talk about their research."

In the summer undergraduate research program, both mentors and mentees expressed satisfaction with their summer experiences. At least one undergraduate participant decided to pursue a Ph.D. based on her experience, and all but one are planning to apply to graduate school.

In the summer high school program, all the participants enjoyed themselves. At the end of the first week, one girl wrote, "This program is really good. It's great to get people interested and acquainted with computers. Some schools don't offer courses like this." Another wrote at the end of the second week, "Nice to meet women working and enjoying computer work." Finally, another girl neatly summed up our goal in the program, writing "This program helped me to see what careers are available in computers and what topics there are to explore." There is no question that for many girls in the summer program we achieved this goal.

When high school summer participants were asked to name their favorite activity, e-mail and the World Wide Web (or Internet) tied for the most popular. Over the two-week period, the average number of e-mail messages sent by participants was over 93! Five of the six most popular activities were laboratory activities, and the sixth was "making new friends." A typical comment at the end of the program was, "I had a really good time. I learned a lot and it was very interesting. I hope I will be able to come to the next one." Overall, a total of 83% of the girls wrote that they would come back if given the chance[6].

Conclusion

Most of the undergraduate and graduate students who participated in PipeLINK activities over the year are still Rensselaer students, so it is too early to determine whether PipeLINK is achieving its goal of retaining women in the computer science pipeline. However, anecdotal evidence is encouraging. Three PhD students chose to mentor undergraduates in the summer program, and they are considering teaching careers. One senior who graduated and took a job hopes to participate in future events as an industry contact. A Masters student is considering becoming certified as a high school computer science teacher. Each of these participants, in her own way, is planning to become a visible female role model for future computer scientists.

For the high school participants, the most interesting aspect of our program was the activity days and two-week summer program. The electronic mentoring system was

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popular for its e-mail aspect, but not as popular for its bulletin boards. We believe that was due to its late start in the program, and our small amount of physical contact with the high schools (only one visit per high school). We believe that increasing the contact with the high schools (a visit once every two weeks) will improve this part of our program.

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